

The Working Memory Deficits in Post-Traumatic Stress Disorder and Relevant Interventions

Jiayi Qian*

Department of Psychology, Faculty of Biology, Medicine, and Health, School of Health Sciences,
University of Manchester, United Kingdom

*Corresponding author: jiayi.qian-5@student.manchester.ac.uk

Abstract. Working memory is one of the essential abilities. When people have Post-Traumatic Stress Disorder (PTSD), their working memory is also impaired, mainly reflected in aspects of capacity and updating. When people directly face the disaster, it may bring serious psychological consequences and indirectly affect the injured people, leading them to suffer from PTSD. Some factors, such as personal and property safety, social support and background, and disaster mortality, can predict the incidence rate of PTSD. This paper aims to improve people's understanding of PTSD and working memory impairment and provides some insights and guidance for future research. By discussing recent studies, it can be found that PTSD patients have poor attention and task execution ability, impaired visual and auditory working memory, and insufficient capacity and updating ability of work memory. Some interventions also trained some components of working memory, which effectively alleviated the related symptoms of patients. There are relatively few relevant studies in this field, and there is a lack of sufficient evidence to prove the impact of working memory on PTSD directly. Future studies should examine this relationship with more systematic experimental designs. This review can provide some suggestions to the design of early intervention programs for at-risk populations.

Keywords: Post-Traumatic Stress Disorder; working memory; intervention

1. Introduction

Working memory is a memory system with limited capacity that manipulates temporarily stored information for complex cognitive tasks, such as learning, language understanding, and reasoning. At a basic level, working memory contributes to many different mental abilities (e.g., control of attention, rehearsal and storage of speech cycles, and operation of visual images). The capacity and updating of working memory are highly correlated with the ability of intellectual learning, reading comprehension, and task execution. For example, a person with good working memory can hold more information during calculation, so their math scores may be better than those with poor working memory [1]. Post-Traumatic Stress Disorder (PTSD) is an event-related disorder, usually caused by exposure to major traumatic events. The core symptoms include invasive memory, adverse changes in cognition and emotion, and persistent avoidance of stimuli related to traumatic events. The duration of the combination of above symptoms needs to be more than one month to be diagnosed with PTSD. Moreover, these interferences cannot be attributed to the physiological effects of certain substances, such as drugs, other diseases, or alcohol. Patients with PTSD have severe and uncontrollable flashbacks frequently. The memory of the injury process continues to appear in their minds, making them panic and suffer for a long time. Also, if there were relevant cues in the surrounding environment, they often recall the process of traumatic events, resulting in intense emotional and physiological reactions. The disturbance may affect the function of patients in social, occupational, and other vital fields, causing pain or impairment. After suffering from PTSD, some patients failed to recover from it and lost the ability to work because of the influence of various symptoms [2, 3].

In a lifetime, more than two-thirds of the general population may be exposed to traumatic events. Neria et al.'s review on post-disaster PTSD investigated the research on human disasters, natural disasters, technological disasters, and multiple disasters. Researchers have found that these kinds of disasters can lead to PTSD, and in general, the prevalence of PTSD may decrease with time. In human disasters, survivors and emergency workers are most likely to suffer from PTSD. Children have an

exceptionally high likelihood of suffering from PTSD if exposed to trauma. The impact of trauma may continue in high-risk groups. The incidence rate of PTSD caused by technological disasters is between 15% and 75%. In contrast, the incidence rate of PTSD caused by natural disasters is often based on the incidence rate recorded by technological disasters and unnatural disasters, which may be due to the low average dose of population exposure [4].

Some studies on PTSD after natural disasters have contradictory statements about the prevalence. They have shown that avoidance symptoms increased with time, while arousal and invasion symptoms subsided. The comprehensive disaster study found that the majority of PTSD among earthquake survivors would decrease over time. Still, many symptoms of survivors who suffered political abuse would increase from 1.5 to 4.5 years after the trauma exposure. The severity of exposure to disasters is related to the risk of PTSD. Some factors can predict the incidence rate of PTSD, such as the immediate risk to life, the degree of physical injury, the death rate, and property damage. The prevalence rate is the highest among the direct victims of disasters, lower among rescue and first aid personnel, and the weakest among the general population. Some studies have pointed out that the prevalence of PTSD in remote areas is lower than in nearby areas. In some studies, female victims' prevalence is higher than men. However, sometimes it is not clear about the relationship between gender and PTSD. Other variables or specific disaster types and consequences may play a mediating role as well. Short-term PTSD may develop into long-term and have specific social and economic consequences. Because natural disasters usually have a broad geographical impact, they often include indirect victims. Disasters also impact people indirectly exposed to trauma and even bring more serious mental health consequences. Certain risk factors and a sufficient level of exposure (even if not direct) may lead to psychopathology after exposure [4].

There are four main intervention methods for PTSD: Cognitive Behaviour Therapy (CBT), Eye Movement Desensitisation and Reprocessing (EMDR), Written Emotional Disclosure, and Prolonged Exposure (PE). Although the degree to which each factor is emphasized may vary in specific studies, CBT intervention has four critical elements for PTSD symptoms: anxiety management, psychological education, exposure, and cognitive reorganization. The principle of PE therapy includes patients being systematically exposed to previously avoided trauma-related stimuli through in vivo means or imagination. EMDR includes history and treatment planning, assessment and identification of trauma memories, preparation of self-control techniques, engagement, and desensitization, etc. Written emotional disclosure invited the participants to provide written descriptions of traumatic experiences. Studies on these interventions showed that after the treatment of these four interventions, PTSD symptoms were significantly reduced or improved. Studies in some minor areas showed that after CBT treatment, patients' anxiety and self-confidence showed additional improvement. General psychopathology scores and BDI were significantly reduced, and depressive symptoms were relieved. After PE treatment, there was no therapeutic effect on psychotic symptoms, but the tendency was reduced considerably. Moreover, compared with the EMDR group, PE had more advantages in the complete remission of PTSD symptoms. After EMDR treatment, the general pathology, pain, anxiety, and depression symptoms were significantly reduced [3].

A disaster is a traumatic event that may affect the physical and mental health of the victims, and a large part of them may suffer from PTSD later. PTSD after the disaster is related to a series of factors, including the level and characteristics of event exposure, social background and support, and personality characteristics. Flashback is one of the main symptoms of PTSD. Working memory can manipulate the temporarily stored data, which may have certain effects on flashbacks and other symptoms of PTSD. Some interventions also involve working memory. However, the literature on working memory and PTSD is relatively limited and is not in the mainstream research direction as mentioned above. Therefore, this review aims to discuss the topic at different levels to improve people's understanding of PTSD and working memory. This review article can provide guidance and ideas for related research and interventions in the future.

2. Working Memory Functioning and Trauma-Related Symptoms

2.1 General Cognitive Deficits in PTSD

Some recent studies have shown that one of the critical features of PTSD is impaired cognitive function. For example, in the study by Jennifer et al., researchers used 14029 middle-aged women as samples [5]. They used questionnaires, scales, and a Cogstate Brief Battery to study whether depression and women's cognitive decline were related to increased trauma and PTSD symptoms. The Cogstate Brief Battery is a self-management online battery that contains four tasks: detection, one back, identification, and one card learning. The results showed that the symptoms of PTSD were negatively correlated with measures of learning/working memory indicators and psychomotor speed/attention. Mental disorders were related to poor cognitive function throughout their lives [5].

Furthermore, as working memory in PTSD is impaired, attention and time estimation are likely to be affected as well. Another study investigated the ability of PTSD participants to estimate the duration of supra-second visual stimulation compared to the control group. The subjects participated in cognitive tasks, digit span tasks, time estimation tasks, and attention switching. In the digital span test, they would hear a series of numbers with an interval of one second and were asked to repeat the numbers immediately and then recall in either forward or backward sequence. In the time estimate task, a black circle appeared and turned green on the screen between 1 and 12 seconds in a pseudorandom order. Then each participant was asked to press buttons to estimate the duration of the object tracking, ranging from 1 to 12 seconds. The attention exchange test first asked them to connect the numbers in ascending order and then to join the numbers and letters in ascending but alternating order. It was found that the PTSD group had a higher average time estimate and higher variability in time estimation. Moreover, the proportional deviation of PTSD was positively correlated with the time required to complete the switching attention task and negatively correlated with all digital span indicators. By summarizing the Information, Vicario and Felmingham found that PTSD patients overestimated the duration of the displayed stimulus more than the control group, possibly because of attention difficulties and working memory deficits [6]. Overall, compared with the healthy control group, PTSD patients perform worse in cognitive tasks and overestimate the stimulation time displayed, indicating that they need to spend more time processing information.

2.2 Specific Working Memory Deficits in PTSD

Verbal working memory involves the ability to remember information, and use it to perform activities. For visual working memory, people perceive the identity of objects and the position of things in space at any given time point. It can also play an essential role in finely processing traumatic images. Most of the tests this paper mentioned before mainly tested the auditory working memory and found that this part was damaged. It is also important to understand whether the visual working memory is impaired or not. Swick et al. studied veterans divided into a PTSD group and a paired control group [7]. The subjects were asked to complete the working memory task. They learned four item sets and then were asked to judge whether a probe stimulus was the recent one or not. Then they also finished a series of questionnaires. The researchers used the same task requirements to test language and visual working memory. The results showed that PTSD patients had significantly more errors than the control group, and visual and verbal working memory was impaired [7].

Working memory can be divided into several dimensions, such as capacity and updating. Working memory updating includes the switching between maintenance mode and update mode. The updating ability is crucial to the effective operation of working memory and many advanced cognitive functions, such as reasoning and navigation. The impairment may lead to a decline in the quality of life. In Nejati et al., subjects completed the PTSD checklist, computer n-back task, and digital span task list on the website. The n-back task evaluated the working memory updating function of emotional and non-emotional information in PTSD patients. The researchers selected to use a one-back task. The subjects were asked to indicate whether the current stimulus matched the previous stimulus in the sequence. The results showed that the working memory of PTSD patients was lower

than that of ordinary people, but there was no significant difference between them in the working memory of emotion and neutral stimuli. General dysfunctional working memory updating leads to working memory defects in PTSD, making it difficult for patients to remember new information and forget irrelevant materials [8].

3. Relevant Intervention in PTSD

If it is true that working memory problems can lead to more severe PTSD symptoms, then training working memory should help patients improve their symptoms. Simon et al. studied the occurrence of intrusive, traumatic memory in patients with long-term PTSD after using a Visuospatial Interference intervention method during 5 to 10 weeks of hospitalization [9]. Subjects were required to keep a diary and complete questionnaires during the study. The intervention includes two stages. The first is the memory reminder process. Patients report one of the intrusive memories in the diary as detailed as possible as the goal. The second part is a 25-minute Tetris game. Tetris followed a memory reminder program that can reduce the occurrence of intrusions. The intervention started from the second week or the third week and lasted until the last intervention one week before discharge. After the start, the patients received a weekly intervention course for the study. The results showed that the frequency of intrusive memory after the intervention was lower than the control group, which proved the effectiveness of working memory training on PTSD symptoms [9]. By combining visuospatial cognitive task intervention with a potential reconsolidation-update mechanism, this intervention helped patients reduce the frequency of uncontrolled intrusive memory.

In addition, affective working memory training (aWMT) can help adolescents with PTSD improve their symptoms. Schweitzer et al. studied the effects of aWMT on the emotional and cognitive functions of adolescents with PTSD compared to placebo training. In the experimental phase, the subjects completed the Go/NoGo task and a set of questionnaires. The Go/NoGo task was used to measure cognitive control. Subjects were required to suppress their responses to all presented geometric shapes except triangles within 500 milliseconds. Then they completed aWMT or placebo tasks. AWM was a dual n back task requiring participants to update and maintain the information, including words with emotional expressions and faces with emotional expressions. Participants had to indicate whether the word they heard was the same as the word heard n trials ago and whether the face they saw was in the same spatial location as the front is seen n positions later (n was always titrated at the participant's best performance level). Notably, to obtain the best task performance, the subjects must pay attention to the content of the words and ignore the emotional expression of the face. The results showed that adequate working memory helped improve PTSD symptoms and increase the use of adaptive emotion regulation strategies. After the intervention of aWMT, the subjects showed stronger cognitive control ability [10, 11]. The effectiveness of these interventions indicates that adequate working memory and improvement in updating and arousal can help reduce or alleviate PTSD symptoms and help at the cognitive level.

4. Conclusion

In general, PTSD patients have prevalent cognitive and working memory deficiencies, mainly reflected in attention, task processing duration, and working memory update, operation, and capacity. Patients may need more time to process and perform tasks, and often perform worse in cognitive and working memory-related tasks. These are direct or indirect evidence of impaired working memory after PTSD. In terms of intervention for PTSD, in addition to some mainstream interventions, such as CBT, some studies have also proved that if the intervention can improve working memory or some dimensions of working memory, such as capacity, some typical symptoms of PTSD can be effectively reduced. One limitation of previous intervention studies is the relatively small sample size. Future studies should include a larger sample size to increase the generalizability of the results. This review

can provide some guidance to the intervention studies and practices for people who experienced traumatic events.

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